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REPORT

OF THE ENGINEERS

TO THE

COMMISSIONERS OF DRAINAGE

OF THE

CITY OF BROOKLYN,

UPON A PLAN FOR THE

DRAINAGE OF WARDS FIRST, THIRD AND SIXTH.

SEPTEMBER 10, 1857.

BROOKLYN:
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In Brooklyn Board of Sewer Commissioners,

September 22, 1857.

The Report of J. W. Adams, Resident Engineer Sewerage Department, was presented, read and accepted, and 1,000 copies ordered to be printed, under the direction of the Clerk of the Board.

J. CARSON BREVOORT,

Secretary.

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ENGINEER'S OFFICE,

SEPTEMBER 10, 1857.

TO THE COMMISSIONERS OF DRAINAGE

OF THE CITY OF BROOKLYN.

GENTLEMEN:

In submitting for your approval a Plan for the Drainage of a Section of the City of Brooklyn, a few remarks will not be amiss on the subject of Drainage generally, called for in view of some diversity of opinion existing as to the principles upon which a system of Drainage should be projected.

The subject of drainage has not, until very recently, excited much attention in this country. Several large cities however, are now making efforts to introduce a proper system and method in their Drainage, but too little has been accomplished yet to enable us to quote results, and we are driven for documentary, or indeed any kind of evidence on the subject, to the experience of older countries.

The English Parliamentary Reports on this subject, within ten or twelve years past, have become quite voluminous, and in their efforts to devise a general system for all towns, much conflicting testimony appears. Up to

the year 1848, the details of the sewerage arrangements of London were under the control of seven distinct boards of management, or district commissioners. They were united in that year under one commission, called the "Metropolitan Commissioners of Sewers," embracing in their supervision about one hundred square miles of area, some two thousand miles of streets, and one thousand miles of sewers. Some of these structures are of enormous magnitude. The Fleet street sewer, for instance, being 12 feet high and 12 feet wide—being, at the outlet, $18\frac{1}{2}$ feet high, draining 4,500 acres of land, and at one place 68 feet below the surface of the ground. Others, of less magnitude, were 10 by 8, 8 by 7, 6 by 4, and of various dimensions and shapes, but none in any street less than 4 feet 2 inches, by about 3 feet in width.

A series of experiments were instituted about this time, for the purpose of ascertaining the proportion of decomposed animal or vegetable matter, and waste from the refuse of the streets merely held in mechanical suspension. It was found to amount to 1 part in 96; taking the average velocities of the current at the ends or outfall of the sewers; and it appears that over 5,400,000 cubic feet of solid matter had been carried to the Thames yearly from a limited number of sewers, and by the force of the water alone, and yet all these sewers are built in recognition of the principle, that it is necessary the sewer should be large enough for workmen to enter and remove this matter by hand—their very dimensions in many cases create such a necessity by diminishing the force of the flow. In one division alone, embracing 48 miles of sewers, over 2,000 loads of sewerage had to be annually removed by hand.

In July, 1849, a Report was received from the Engineer to the Metropolitan Commission (Mr. Philips), embracing plans and estimates he had prepared for the

Drainage of the Metropolis. In this Report, the principiples of Town Drainage were laid down as follows:

1*st.* "That two outfalls, independent of each other, should be provided: one for the discharge of natural or land and surface waters, and the other for the discharge of artificial or house and soil drainage.

2*d.* "That in order to perfectly drain the subsoil, so as to free it from damp, and to carry off as quickly as possible the natural waters, a system of permeable land drains and sewers should further be provided, to discharge into the natural water courses and rivers.

3*d.* "That as outfalls are already provided by streams and rivers for the discharge of the natural waters, it is only necessary to provide separate and proper outfalls for the discharge of the artificial or house and subsoil drainage, which outfalls should convey the sewerage as fast as it is produced, to a depot at a convenient and unobjectionable place, quite clear of and below the town.

4*th.* "That, in order to carry off the house and soil drainage, without contaminating the atmosphere of the town by the escape of effluvia through the numerous inlets, as is at present the case, a system of impermeable drains should be provided, distinct and separate from the permeable land drains and sewers, to discharge without intermission into the said artificial outfalls, independently of the rivers.

5*th.* "That at the main outlet a depot should be formed, and works established, for raising the sewerage, and connecting and distributing the same for agricultural and horticultural purposes.

It will be perceived that the economical value of sewerage formed an element in the system of drainage proposed, as did also the necessity for a system of subsoil drainage. As to the first, although it is asserted by Leibeg and Boussingault, that the fertilizing principle or nitrogen, from one individual in a year, is more than equivalent to the growth of 800 lbs. of wheat, or to the quantity needed for the daily supply of 2 lbs. of bread, yet we are not prepared in this country to recognize its importance to the extent of hampering in any degree,

our efforts to be rid, even at a pecuniary loss, of the refuse of our cities. This will one day receive undoubtedly, all the attention which its importance demands; but, for the present, all idea of collecting the sewerage for agricultural purposes will be laid aside; the more particularly, that our position at tide-water is such as to give us the means of its complete removal, which is not always the case elsewhere.

In the second place, in reference to subsoil drainage, it need form no part of our general system to provide for it. A sound and proper system of construction will amply suffice to maintain basements and cellars in a perfectly dry condition, if all sewerage and surface water are, as they should be, discharged into the sewers. The drainage of the subsoil to the entire depth of foundation, is a want which cannot arise, if the structures to the level of the ground be made waterproof, which our builders will find little difficulty in effecting.

The first, second, third and fifth principles, as laid down by Mr. Philips, need not occupy our attention, and modifying the fourth, narrows our view to the simplest and most effectual (including economical) method of removing the ordinary rain-falls and storm-waters, (being the surface drainage,) and including in the same channel of conveyance, the house drainage or sewerage proper.

Sewers are properly mere passages for the sewerage, but they are so only while the matters sent into them are induced to continue in motion by the declivity of the sewers, or by the artificial force of water. They become, without those aids to motion, but elongated cesspools, and the decomposing matters remain for days, weeks and months it may be, poisoning the air and subsoil by their exhalations, until the nuisance calls for official attention, and the expensive and disgusting process is resorted to of

opening and removing the contents by hand. In order to have an effectual drainage without contaminating either the atmosphere or subsoil by the escape of sewage water or effluvia—*First*, A system of impermeable drains should be provided, through which the waste matter both of the surface and from the dwelling, assisted by the water supply, are removed to their outlets at tide-water, forming a combined system of water supply and drainage; and *second*, such a fall and dimensions should be given to the drains and sewers, as shall insure if possible, their self-cleaning action without having recourse to removing the contents of the sewers by hand.

That this may be accomplished in Brooklyn in view of the quantity of water at command, as also the inclination attainable for the main sewers, (at all events in that part of the city now under consideration,) there can be no question. The method of making a fall most effectual, and concentrating the flow or scouring effect of the water as much as possible, are deserving and have received in this connection, the most careful study and attention as a primary element in a self-acting system of drainage.

In 1850, and before any general plan for the drainage of London had been determined on, the Government had appointed a "General Board of Health," so called, to inquire into the proper measures to be adopted for improving the health of towns. This Board reported in February, 1854, and the Government avowed a preference for the system proposed by it, rather than that of the Sewer Commissioners. The Commissioners of Sewers and the Board of Health were at issue as to the cheapest and best way of draining houses.

For the arguments on either hand in support of their respective views, see Appendix A.

The method finally adopted in London, and in accordance with the public sentiment manifested by the continually increasing outcry as to the pollution of the Thames water, was a system of intercepting sewers, by which the drainage was caught before reaching the river, and carried down some miles below the city and discharged at high water, to be deodorized for agricultural use.

By a Report dated July of this year (1857), it appears that provision is to be made for draining 226,784 acres of area, with a population of 3,979,000, the estimated amount of sewerage being 27,855,000 cubic feet in twenty-four hours; and the estimated rain-fall to dilute this sewerage being at the same time 183,059,000 cubic feet, being one-quarter inch per diem over the whole area drained.

In this new purpose as a channel for the conveyance of immense volumes of water and sewerage, it is to be presumed the large sewers of the Commissioners were selected rather than the pipes advocated by the "Board of Health;" and yet we find that the discharge from nearly twenty square miles of this area is to be passed under the River Ravensbourne by a pipe four feet in diameter, acting under pressure, as in water pipes. This new feature being introduced, of withdrawing the sewerage from the River Thames within the city, and the comparatively vast extent of area drained, must have given the preponderance in favor of the larger dimensions.

However that may be, and failing any detailed statement of dimensions, we are free to use for our limited areas in this city, the argument of the "Board of Health" in favor of the pipe sewers, so far as they are applicable to our use, omitting all consideration of the question of back-draining so called, as notwithstanding its manifest

economy and other advantages, it is wholly inapplicable in this city. From a great mass of testimony from all parties, given in the Parliamentary Reports, it appears that under certain circumstances, viz.: ample fall or inclination, careful laying with strict attention to preserving the joints tight, and uniformity in the grade line, and a sufficient supply of water, the concentrated flow in the pipe sewer will carry through any matters which will find their way into the pipe, under a proper system of supervision.

We have relied with some confidence on these Reports, as embracing the best evidence we have in print on the subject of drainage; and as the estimated cost of the new works, for which this system was adopted, (at least in part,) amounted to over $15,000,000, it is to be presumed that all available information on the subject-matter had been sought. To show the kind of evidence upon which our advocacy (within certain limits) of the use of pipe-sewers rests, we cite two cases (Appendix B) from the Report of the "Board of Health" in 1855; and also an extract from "Reports to the Metropolitan Commissioners of Sewers, on the Working of Pipe Sewers. Parliamentary Reports, 1855." The first of these, from the Report of the "Board of Health," was published in the Report of the Water Commissioners of Jersey city, in 1853, in support of the views of their engineer, Mr. Whitwell, who advocated the use of pipe sewers for that city, in lieu of the large brick sewers heretofore in use. Subsequent experience having confirmed the value of these experiments, justifies their republication in this place.

If to these experiments and statements of practical working, we add the fact stated in the same report, that at the date named, 347 miles of pipe sewers were laid in London alone, draining over 27,000 houses, with

at least the population of the City of Brooklyn, and at a greatly reduced cost of construction and working over the ordinary brick sewers, we will have an overwhelming weight of testimony in favor of their adoption in this city for the drainage of the 1st, 3d and 6th wards, the section of your city now under consideration.

The capacity of sewers should be regulated by a consideration jointly of the quantity of sewage to be conveyed through them, and of the rate of fall or inclination. The capacity varying directly as the quantity, and inversely as the fall, since the greater the fall, the more rapid will be the discharge. The general principle would seem to be sufficiently simple, yet there are anomalies in the movement of running water which baffle all our attempts at investigation, as without special experiment on a large scale, we are liable to be misled.

Of all branches of science, there is none more intricate or more liable to misapplication, in the use of the formulas deduced by mathematicians for practice, than that treating of the motion of fluids, whether in pipes or open canals, for the reason that the experiments upon which the formulas were based, have been for the most part from necessity, conducted on a comparatively limited scale, and are found in practice not to hold true in all cases, on a larger scale.

The formulas hitherto in use for calculating the dimensions of sewers, have been those used in hydraulics for the flow and distribution of water; but the circumstances in the two cases differ so widely as scarcely to admit of the application of the same rule to both. Whilst the water supply preserves a pressure on all the pipes, the discharge from the branches will be some function of the head; the main sewer on the contrary, collects from various branches, and discharges its contents to exhaus-

tion, and not under pressure as in the water supply. Yet it has been proved that a sewer discharges much more from the increased velocity, induced by the junction of the small streams, than if the discharge took place under a head; and experiments on the motion of water in sewers scarcely admit of being conducted save on a full scale.

The only experiments of this kind indeed, known to have been made in the sewers themselves, entitled to consideration, have been those conducted by Mr. Roe, Chief Engineer of the Metropolitan Commission of Sewers during a series of years, and presents facts completely at variance with previously conceived ideas on the subject. Nor is it as has been supposed, a matter of indifference of what material the sewers be built, these experiments showing conclusively, that brick sewers or drains when made comparatively smooth by a coating of cement or a glazed stoneware pipe, are kept free from deposit; whilst the same inclination and quantities of discharge failed to prevent deposit with the ordinary brick surface. Confiding in the applicability of the hydraulic rules in use for water supply, to the calculation of the dimension of sewers, the latter have been built in a great majority of cases, much too large for their duty, entailing thereby a greatly increased expense, without any corresponding benefit, and acting injuriously in retarding by their presumed expense, the extension of works of sanitory improvement.

The rule to make a sewer in all cases large enough for workmen to operate within it, is believed to have been discovered to account for the practice of so doing, rather than as having directed that practice.

Sewers, as before remarked, are the *passages* of the sewage; the means or power for moving the latter is, or

should be, *water*, rather than wheel-barrows. We have seen the amount it yearly moves in London, and witnessing the operation of a brisk shower in its cleansing effect on our own streets, will give some slight idea of its power to the same effect when its flow is concentrated in narrow and confined channels, an imitation of this process is used largely for cleansing of sewers in the operation of artificial and occasional flushing, after the deposit has been allowed to accumulate. What we recommend is a natural and constant flushing for the prevention of this deposit.

Both theory and experience prove, that with a given fall and length, there will be a greater tendency to deposit in long brick sewers than in smaller pipe sewers. The strongest advocates for the brick sewers will admit that the tendency will be *as great*, and as the brick sewer would only have the advantage of holding a larger quantity of deposit, the preference for them is really on the ground of their *capacity* as cess-pools for retention of solid matter, and not as channels for carrying refuse away. And with the unusually large body of water at your command, and both water supply and drainage works under one authority, you have all the needed elements for a thorough and economical system of drainage.

With reference to the capacity to be given to a sewer. The refuse discharged from houses (which includes the water supplied to them,) and everything which should be allowed to be thrown into a drain, can be carried off by the pipe which will carry this waste water. This fact is well established in London, where the supply of water is limited comparatively, that is to say, the solid matters need no more dilution than the water supply. If the supply of water be several times greater, of course the facility for carrying the solids will be greater. If to this

we add the rain water, the cleansing process is still further benefited, and the waste pipe will require no increase in size, but in the event of sudden and heavy storms, the surcharging of the main trunk may throw the water back into the house; some provision must therefore be made for storm Waters. The yearly rainfall here, may be taken at 50 inches. The daily fall will be less than $\frac{14}{100}$ of an inch, but storms of several inches in twenty-four hours sometimes take place and thunder storms have occured delivering water to the depth of even three or four inches in an hour, but their occurrence are very rare and never of long duration, and being usually in the summer months, part of the water falling would be absorbed by the dryness of the soil or its porosity, part evaporated by the dry roofs and paving, as well as the heat of the atmosphere, and a still larger proportion prevented from flowing to the drains by hollows in the surface, and re-ascends into the atmosphere as vapor, then there is in the resistance the flow experiences from the friction of the entire surface. All of these causes combined, render it unnecessary to provide for the whole of the storm water finding an immediate outlet by the sewer. No serious damage need be apprehended from an excess of rain at remote intervals, except in situations peculiarly liable to inundation, as may be perceived in towns entirely destitute of underground drainage, where the whole fall finds its way off by the surface, as has been the case heretofore in this city, without other than a local and very temporary inconvenience, not sufficient to justify by any means the construction of immensely large sewers, and the expenditure of large sums of money to provide against it. If a rainfall of one inch in an hour be provided for, which is an extremely violent storm, it will be an ample provision. But as we have seen the rainfall cannot, by reason of the natural obstacles above mentioned, reach the sewers as fast as it falls, or in other words the very heavy rains are of shorter continuance than the floods they occasion; therefore the sewers need not be so large as to carry

away or store the above amount of rain in the same time as it falls.

From recorded observations it appears that in a particular district, a rainfall of one half inch in three hours, took twelve hours before the flow in the sewer resumed its ordinary level on areas such as we are considering, and a rainfall of $1\frac{1}{10}$ inch in an hour, and $\frac{3}{10}$ in the next two hours occupied in discharging $15\frac{3}{4}$ hours; those points nearest the outfall draining off first, the more remote next, and some portions would be entirely clear before the water from the most remote points would reach the outfall.

The present plan is calculated for a rainfall of one inch in an hour, to be discharged in two hours, or a discharge of one half a cubic foot ($3\frac{1}{4}$ gallons,) per second per acre of area drained.

A reference to the accompanying plan will show that we have aimed at bringing all the drainage possible into the Bay, between the extreme points of Hamilton avenue and Fulton ferries. Owing to the conformation of the shore all refuse thrown into tide water between these points may be expected to be carried off without further trouble. The whole area drained amounts to 562 acres, covering twenty miles of streets, and requiring sixteen outlets into the Bay, nine of which are short and drain but a single block, and their outlets need not be carried below low water, the remaining seven outfalls should, from their magnitude deliver their contents below low water; of these seven, five are already built, viz:—Fulton street sewer, draining eighty-six acres, at the outfall at the end of dock south of the ferry; Pierrepont street sewer (private,) draining nineteen acres at the bulkhead on the Pierrepont property, at the foot of the street; a private sewer between Montague and Joralemon streets, draining ten acres; Warren street sewer, terminating at

the bulkhead at the foot of the street, draining sixty acres; Hamilton avenue sewer, terminating also at the bulkhead foot of the avenue, near the ferry, draining 113 acres.*

The dimensions of those brick sewers already built are quite ample for the service, Fulton sewer being 6 feet in diameter for a length of 700 feet, and 5 feet in diameter for about 740 feet, and the remainder of its length, 1,600 feet, being eliptical, 4 feet by 5 feet. It terminates at the summit of Fulton street, opposite the Globe Hotel, and is provided with street basins and gully shoots at the corners of all the streets. It discharges two-and-a-half feet below high water.

Pierrepont sewer is 4 feet by 5 feet, and discharges at low water, with a basin and shoot, at foot of Pierrepont street, and is 550 feet in length. Warren street sewer is 4 feet by 3 feet, and traverses the whole length of that street, 2,780 feet in length, and is provided with gully-shoots and basins, and discharges above high water. Hamilton avenue sewer is $4\frac{1}{2}$ feet diameter at its outlet at high water. After the junction of President street sewer, it is reduced to 4 feet in diameter for a length of 1,340 feet, being altogether 2,040 feet in length, and receives at its lower end the sewer, 4 feet by 3 feet, built in each of the streets—Union, President, Carroll, and Summit—as far up each as Columbia street. It is proposed to build a portion of the sewer in Hicks, Joralemon, Pierrepont, State, Baltic, Van Brunt, Columbia (S.), Henry (S.), Coles street and Hamilton avenue, of brick; in all, 12,450 feet in length. All the remaining sewers and branches to be of glazed stoneware or cement pipe. The lower half of the brick sewers to be coated or lined with cement. The Hick street sewer will be egg-shaped,

* In specifying the area drained by these sewers which are built, reference is had to the area which they are capable of draining.

2 feet by 3 feet, from Clark to Fulton street. State street sewer will be 3 feet in diameter as high as Columbia street The Baltic street sewer will be 3.9 by 2.6 as high as Henry street. South Henry street, Hicks and Columbia streets will be, for a portion of their length, each 3 by 2 feet. The Coles street sewer, from its junction with Hamilton avenue to Henry street, and thence to First place, will be 18 inches in diameter. The Hamilton avenue sewer will be extended from its present termination, at foot of Rapelye street, to foot of Nelson street, of brick, 3 feet in diameter; thence to Church street, 3 by 2 feet. The accompanying Plan, to a scale of 200 feet to the inch, exhibits the proposed plan of drainage in detail. All the main sewers emptying into the bay should have cast iron pipes at their outlets, terminating below low water. These pipes need not be larger than from 12 to 18 inches diameter, depending upon the area drained and their fall, and carried out, where practicable, to the end of the piers.

The sewers should be of the best hard brick, well laid in cement, and true and uniform in section. The pipe sewers should be carefully laid, with socket joints in cement, and all connections, including those with main sewer, street shoots and house drains, to be made curved with as long radius as possible. These connections to be built when the mains are under construction. The private or house drains will also be of pipe 5 inches in diameter, and should be put in subject to the inspection and approval of the engineer.

The grade of street sewers generally to be thirteen feet below the level of the curb—custom, both here and in the city of New York, may be considered as having fixed this dimension. In laying these pipes, the greatest care should be taken to insure the accuracy of the levels and bearings, and the precision of joints and connections.

Man-holes for examination and removal of obstructions will be built below the main junction, and wherever else it may be thought desirable.

It is not to be supposed that the advantages in economy offered by this method of pipe sewers (costing at least 50 per cent. less than the ordinary brick sewers) can be secured without a corresponding effort on the part of the managers of the work. In the first place, the best of material and workmanship alone should be allowed in construction; all requisite openings and connections in the mains should be built in whilst under construction, and no breakage into them allowed by private parties under any circumstances; and a rigid supervision be exercised by proper officers, with a periodical inspection of the state of the sewers, and the remedy in the case of obstructions applied at once, without waiting for complaints from residents. Penalties should be enforced for any injuries to the work by introducing or allowing to pass into the drain or sewers any improper substances, such as ashes, cinders, garbage, refuse of various manufactories, &c., which should as at present, be carted off.

Such substances in quantities, will undoubtedly produce a stoppage in pipe sewers as they now do in the brick sewers; but that such stoppage is fatal to the system, by rendering it necessary to break up the street either for its removal or for examination, is a mistake. Efficient means exist (having stood the test of years) for its speedy and thorough removal, and at an expense not one-fifth of that attending the ordinary operation of hand cleaning; yet it is highly desirable that more than ordinary precautions should be taken to prevent the accumulation of street refuse, the gravel covering to new pavements, brick, mortar and building materials of all kinds, which now find their way into the sewers, but which scarcely can be regarded as a proper mode of conveyance for this kind of material.

With such precautions as it will be in your power to adopt, there need be no apprehension that the more economical system of drainage proposed, will not effect all the desired improvement in the health and comfort of that portion of the city where it may be introduced

Respectfully submitted,

JULIUS W. ADAMS.

APPENDIX.

APPENDIX A.

Brief Statement of the Arguments of the Commissioners of Sewers, and the Board of Health, in Support of their Respective Views for and against the Adoption of Large Brick Sewers.

"The 'Board of Health,' advocate the drainage of each house-block by a tubular sub-main, running behind the houses and receiving the sewerage of each by a short tubular branch. They recommend a large reduction of the sizes of drains hitherto employed. For a single house drain they recommend a 4 inch pipe; for the sub-main, receiving several of these, a 6 inch, gradually expanding to 9, 12, and so on up to 20 inch. According as the lengths of the sub-main, and the number of branches received by it increase, such drains they say are self-scouring. The run of water through them is so concentrated, that it keeps them clear of deposit; the branches being very short, and running backward towards the drain behind, instead of forward beneath the houses, towards a sewer in the street, have a quicker fall, and in case of leakage leak into the open air. The cost is so much reduced by this method, that blocks of laborers' houses may be thoroughly drained, and fitted with sinks and soil-pans, for an improvement rate of less than $3 per house per year."

"The Commissioners of Sewers, on the contrary, recommended large brick sewers under the street, in front of the house, beneath each of which they carry a long drain from back to front, strictly forbidding more than two houses being relieved by one pipe-drain—a system which, whether otherwise good or not, certainly entails an enormous increase in the expense to the house owners, and thereby redouble the resistance, on their part, to sanitary improvement."

"The Commissioners of Sewers lay great stress on the independence secured by their system to each house owner, whose premises are traversed by his own drain only, which he may take care of or neglect as he pleases, as its stoppage can only injure himself. They allege against the Board of Health plan, that it trespasses on private property; that any stoppage of the tubular submain causes all the houses higher up to suffer, and renders it necessary for workman to enter private back-yards to search out and remedy the evil."

"They also deny the self-scouring property of the tubular sub-mains, and refer in support of their views, to several hundred cases of stoppages in tubular drains, collected in a report of Mr. Bazelgette's."

"The Board of Health, on the other hand, declare the householders' pretended independence on this plan to be illusory, seeing that the big street sewer is, nine cases in ten, an elongated cesspool, where the sewerage of each stagnates to the detriment of all, while the stoppage of a branch drain, running beneath a house on the old plan, often causes stench in the houses on the other side."

"Against the inconvenience of an occasional invasion of the back-yards by workmen, they set the greater inconvenience of periodical invasions of the streets, and stop-

page of the traffic, besides tearing up of kitchen floors, to get at foul drains under the house."

"In reply to Mr. Bazelgette's report, they bring forward examples by hundreds of pipe sewers working admirably, year after year, and attribute such stoppages as have occurred to errors incidental to this first introduction of a new system, errors which once known, may be avoided."

"Among these they cite the use, at first starting, of drain pipes which were too thin, so that they broke under the pressure of superincumbent earth, the uneven laying and careless joining of pipes by the jobbing builders, often employed in this work; the use of soil-pans with ducts as large as the pipe drains to which they led, and, above all, the often scanty and intermittent supply of water to the system."

"They further point out that a population accustomed to open privies and cesspools, available as receptacles for solid refuse of every kind, (refuse properly due to the ash-pit,) have to go through a transitional period of a few weeks, while they are learning that such practice leads to stoppage of the new circulating system, and must be abolished, along with the old stagnant cesspools. They say that many of the tubular sewers, put down as failures in Bazelgette's Report, are at this moment working perfectly well, for which reason they take all his allegations with very great reserve. They point, with some reason, to Lambeth square, where the Commissioners have allowed thirty-two houses to be drained by four tubular back-drains, which act perfectly well, quite as well as thirty-two separate drains could act, though these would have cost eight times as much; and they ask, why this eight-fold cost should be imposed upon London at large, by the very same authority which sanctioned, in this square, the combined drainage which is found to work well."

APPENDIX B.

EXPERIMENT MADE, UNDER THE DIRECTION OF THE METROPOLITAN COMMISSION OF SEWERS, BY WM. HALL. (GENERAL BOARD OF HEALTH REPORT, 1855.)

"The main line of sewer in Upper George street (Fig. 1) is 5 feet 6 inches high, and 3 feet 6 inches wide, and runs from the Edgeware road to Manchester street, where it falls into the King's Scholars' Pond Sewer. There was laid a 12 inch pipe, 560 feet long, upon the invert of the main line, and a head-wall was built at the end of it, so that the whole of the sewerage discharged by the collateral sewers above the pipe, as well as what sewage may find its way independently into the upper part of George street, is forced to pass through the pipe. " The whole area drained by the sewers running into the 12 inch pipe in George street is 213,778 square yards, or about 44 acres. Observations are being continually made on the work, and the results are as follows:—The velocity of the stream in the pipe has been observed to be four-and-a-half times greater than the velocity of the same amount of water on the bed of the old sewer. As the force of a stream is proportionate to the square of its velocity, the draining power of the concentrated stream in the pipe would be above 20 times as great as that in the wide sewer; consequently, stones, &c., which might rest in the latter, would be swept away by the more rapid flow. The pipe has not been found to contain any deposit; but during heavy rains, stones have been distinctly heard rattling through it. When the pipe is nearly filled, the velocity and concentration of the water are sufficient to clear away any matter which may have been drawn into the pipe from the large sewers, and much of which matter, it may be presumed, would never enter a well-regulated system of pipe sewers; also, the force of water issuing from the end of the pipe is sufficiently great to keep the bottom of the old sewer perfectly clean for 12 feet in length; beyond this distance, a few bricks and stones are deposited, which increase in quantity as the distance from the pipe increases. Beyond a certain distance, mud, sand and other deposits occur, to the depth of several inches, so that the stream there is wide and comparatively sluggish, and, being dammed back by the deposit, exerts an unfavorable influence on the flow of water through the pipe. On the invert of the original sewer, which now forms the bed of the pipe, deposit was constantly

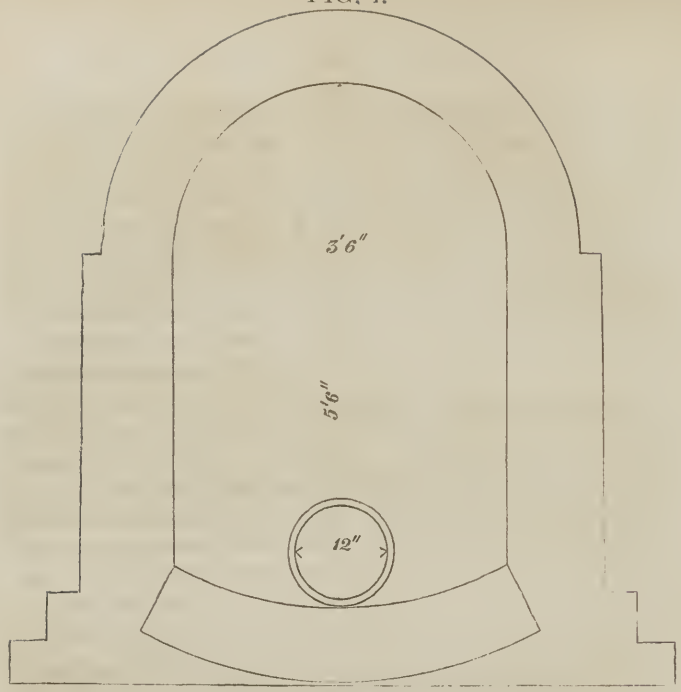
accumulating, and was only partially kept under by repeated flushings. "The superficial velocity of the water in the pipe is generally three, four and five times greater than the superficial velocity which obtained under the same circumstances in the original sewer; and the velocity of the whole mass of water in the pipe approximates much more to its surface velocity, as ascertained by a float, than does the velocity of the whole mass of water in the sewer approximate to its own surface velocity.

"On one occasion, the sewer in Upper George street was carefully cleaned out immediately below the pipe, and a quantity of deposit, consisting of sand, pieces of brick, stones, mud, &c., was put in the head of the pipe. The consequence was, the whole of the matter passed clear through the pipe, (560 feet long,) and much of it was deposited on the bottom of the old sewer, at some distance from the end."

Experiment Made to Determine the Amount of Sewerage from 1,200 Houses.

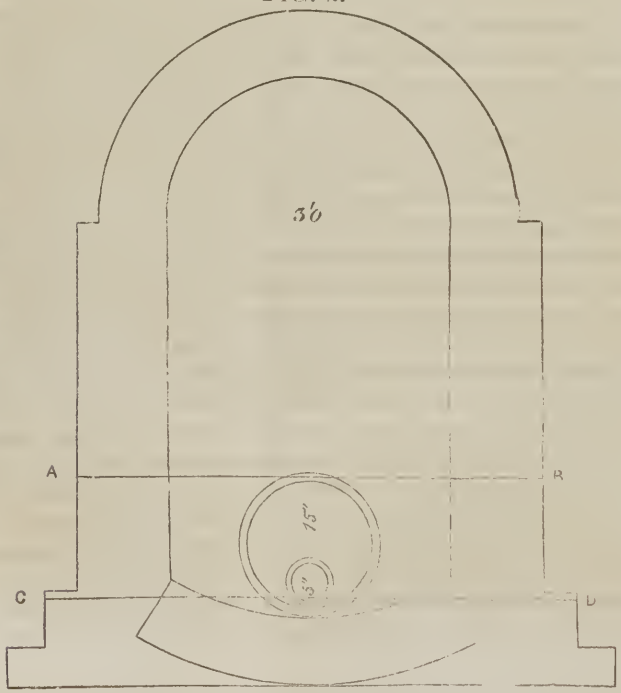
"In this sewer, (Fig. 2,) which has a flat segmental bottom, three feet wide, a sectional area of 15 feet, and an average fall of 1 in 118, the deposit from the 1,200 houses regularly accumulated at the rate of 6,000 cubic feet per month. But a pipe of 15 inches diameter, placed along the bottom of this sewer with a somewhat less inclination, (1 in 155,) kept it perfectly clear of deposit. The average flow, without rain-fall, was about 51 gallons per hour per diem. The absolute drainage, apart from the rain water from all the 1,200 houses, would have passed through a 5 inch tube, (of the relative size of the smaller ones shown within the 15 inch tubular pipe placed along the bottom of the brick sewer,) or not one-third the area of the minimum-sized drain which had, up to the time of investigation, been declared and enacted in the Metropolitan Building Act to be necessary for a single house—namely, one of not less than 9 inches in diameter."

FIG. 1.



Area Drained, 44 acres.

FIG. 2.



A. B. Flow of storm water from 43 acres of paved and covered surface.
C. D. Ordinary flow of the sewerage from 1,200 houses.

EXTRACT

FROM

GENERAL COMMITTEE MINUTES,

JANUARY 9, 1857.

"That each District Engineer do report on the present state of such pipe sewers in his district as in his judgment afford a fair sample of the working of the system, including in his selection the pipe sewers referred to in Mr. Bazalgette's Report, and stating his view of the causes to which the alleged failures in the pipes referred to in that report were due; and that the District Engineers be severally authorized to make the necessary openings for effecting the examination above directed; and that the Surveyor, Mr. Smith, be also instructed to report the results of his observation and experience of pipe sewers, with illustrations from individual cases.

REPORT OF MR. G. ROE, ENGINEER.

"Pursuant to the above order, I have made examinations of the various pipe sewers in the streets and places hereinafter mentioned.

Spitalfields, &c., Level, Hungerford Street.

"*Twelve inch pipe sewer*, 650 *feet in length.*—Pipes sound; gradient 1 in 120; laid down February, 1849; receives the drainage of 42 houses and two gullies; when opened, had a run of half an inch of water; no deposit, which was the case when inspected by Mr. Bazalgette in 1853."

Regent Street, Mile End.

"*Twelve inch pipe sewer*, *length* 700 *feet.*—Pipes sound; gradient 1 in 161; laid down in 1851; receives the drainage of 42 houses, two schools and three gullies; when opened, had seven-eighths and one-sixteenth of deposit, and half-an-inch run of water. When this pipe sewer was inspected by Mr. Bazalgette in 1853, contained three-and-a-half inches of deposit. The above pipes have been flushed."

Canton Street, Poplar.

"*Twelve inch pipe sewer*, *length* 580 *feet.*—Pipes sound; gradient 1 in 200; laid down in February, 1851; receives the drainage of 45 houses; when opened, had a run of water of three quarters of an inch, and deposit one inch. This sewer has been flushed."

Miss Wade's Estate, Grundy Street, Poplar.

"The drainage of this estate was applied for in 1849, laid down in 1850, and was intended to drain 54 houses, which consist of 6, 9, and 12 inch drains; lengths varying from 200 to 260 feet; gradient about 1 in 120. At present there are about 30 houses drained; when opened it contained seven-eighths deposit and water together. This drain was inspected by Mr. Bazalgette in 1853, and was clean. This has not been flushed."

Bridge Street, Stepney.

"*Twelve inch pipe sewer*, *length* 500 *feet.*—Gradient 1 in 120; laid down at private expense in 1849 and 1850; receives the drainage of 70 houses and five gullies; when examined, had two inches of hard deposit, and two-and-three quarter inches of water. On inspection, I find that four of the gullies have no cess-pits; consequently, deposit finds its way direct into the sewer. The gullies in question will be altered forthwith, and the sewer flushed."

St. Jude Street, Bethnall Green.

"*Eighteen inch pipe sewer*, 360 *feet in length.*—The pipes sound, but not more than a quarter-of-an-inch in thickness; gradient 1 in 240; laid down in December, 1848, and receives the drainage of 37 houses and two gullies; when opened, had a run of 1 inch of water over 2 inches of hard deposit; was flushed in August, 1854; had 3 inches when examined by Mr. Bazalgette."

Shacklewell Lane.

"*Twelve inch pipe sewer*, 1,250 *feet in length.*—Pipes sound; gradient 1 in 60; laid down in November, 1851, and receives the drainage of 40 houses; when opened, had a run of one-and-a-half inch of water over one-and-a-half inches of soft deposit; was flushed out in August, 1854."

Dog Row, Bethnal Green.

"*Nine inch pipe sewer*, 578 *feet in length.*—Pipes sound; gradient 1 in 120; laid down in August, 1849, along a black ditch, at a depth of 11 feet from the surface, and receives the drainage of 63 houses; when opened, had a run of two inches of water over one-and-a-half inch of deposit; was flushed in August, 1854; had seven-and-a-quarter inches of deposit when examined in 1853, by Mr. Bazalgette. The accumulation of deposit in 1854, was no doubt caused by a temporary obstruction."

Finsbury Division, Back of New Gloucester Street, Hoxton.

"595 *feet of* 12 *inch pipe sewer.*—Pipes sound; gradient about 120; laid down in April, 1848; receives the drainage of 39 houses and two gullies, which by closing a flushing gate can be increased to about 200 houses. This was the case when examined, and there was a run of about two inches of water; no deposit; bad smell, and when flushing gate was opened, the water increased to 11 inches, carrying all manner of substance in suspension; flushed about every fortnight."

Dove Row, Haggerstone.

"440 *feet of* 12 *inch pipe sewer.*—Sandy sub-soil; pipes sound, but joints not made good; gradient 1 in 480; laid down in 1851; receives the drainage of about 25 houses and three gullies; when opened, had about five-and-a-half inches of silty deposit and water,

with a very slight current. I attribute this to the pipes connecting on a level with the invert of the 3 feet 9 inch sewer, directly under a ventilating shaft where there is four-and-a-half inches heavy deposit; the passing of road drift down the gullies, and the sand getting into the pipe through the open joints.

Experiments made by Mr. Roe, at the suggestion of the Metropolitan Sanitary Commissioners, to Ascertain the Comparative Rate of Flow through Glazed Pipes and Brick Sewers of the same Size. General Board of Health Report, 1855.

TABLE OF COMPARATIVE TIME OF RUN OF WATER THROUGH BRICK DRAINS AND GLAZED PIPES.

INCLINATION.	DEPTH OF WATER.	TIME THROUGH GLAZED PIPES.	TIME THROUGH BRICK DRAINS.
Level,	5	38	50
1½ inches in 50 feet,	3½	25	36
1¾ " "	5½	19	27
2 " "	4½	16½	25
2¼ " "	3	18	26
2¾ " "	6	13½	21½
3¼ " "	4	15	22

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